TABLE – TOP NUCLEAR FUSION DRIVEN BY CLUSTER COULOMB EXPLOSION

J. Jortner
School of Chemistry, Tel Aviv University

We shall focus on recent theoretical and computational studies of photoinduced ultrafast response, dynamics, reactivity and function of finite systems dynamics under extreme energetic and temporal conditions. Ultrafast and ultrahigh phenomena pertain to extreme ionization of molecular clusters and nanostructures in ultraintense laser fields (peak intensities $I_M = 10^{15}$–$10^{21}$ Wcm$^{-2}$, with $I_M = 10^{21}$ Wcm$^{-2}$ constituting the highest light intensity on earth), ultrafast femtosecond dynamics on the time scale of nuclear motion, attosecond–femtosecond electron dynamics, the production of ultrahigh charges in completely ionized molecular or elemental clusters, and the attainment of ultrahigh energies (keV–MeV) in Coulomb explosion of multicharged clusters and nanostructures. Coulomb explosion of clusters and nanostructures transcends chemical–physical dynamics towards the driving of nuclear reactions involving table-top nuclear fusion and nucleosynthesis of astrophysical interest.

A significant novel development involves dd nuclear fusion driven by CE (NFDCE) in an assembly of deuterium containing heteronuclear clusters, e.g., $(\text{D}_2\text{O})_n$, $(\text{CD}_4)_n$ or $(\text{DI})_n$, for which compelling theoretical-computational evidence was obtained and which was experimentally confirmed at Saclay, at the Lawrence-Livermore Laboratory in California, at the Max-Born Institute in Berlin, and at the Chinese Academy of Sciences. We shall emphasize the dramatic enhancement of D$^+$ ion energies and dd nuclear fusion yields triggered by energetic boosting of D$^+$ nucleons driven by CE of heteroclusters of deuterium bound to heavy atoms. Recent studies addressed NFDCE within a single nanodroplet. These remarkable developments accomplish an 80 years quest for the attainment of table-top nuclear fusion in the chemical physics laboratory. Other developments pertain to table-top nucleosynthesis in assemblies of methane, ammonia and water nanodroplets, which are of astrophysical interest, being of importance in the CNO cycle in hot stars.

References
